CLAIMS

WE CLAIM:

1. A turbine blade proximity sensor system for sensing proximity of each of a plurality of rotating turbine blades to a non-rotating turbine component, comprising:

a sensor coil;

an oscillator circuit coupled to the sensor coil and operable to supply a sensor signal that is frequency modulated based on the proximity of the sensor coil to each of the turbine blades; and

a frequency modulation (FM) detector circuit adapted to receive the frequency modulated sensor signal and operable, in response thereto, to supply a proximity signal having an amplitude that varies with, and is representative of, the proximity of each of the turbine blades to the non-rotating turbine component.

2. The proximity sensor system of Claim 1, further comprising:

display coupled to receive the proximity signal from the FM detector and operable, in response thereto, to supply a visual display of the proximity of each of the turbine blades to the turbine shroud.

3. The proximity sensor of Claim 1, wherein the FM detector circuit comprises an FM demodulator.

4. The proximity sensor of Claim 3, wherein the FM demodulator comprises a ratio detector.

5. The proximity sensor of Claim 1, wherein:

the oscillator circuit is configured to wirelessly transmit the sensor signal; and

the FM detector circuit is configured to wirelessly receive the transmitted sensor signal.

6. The proximity sensor of Claim 1, wherein the oscillator circuit includes one or more capacitance circuit elements electrically coupled in parallel with the sensor coil.

7. The proximity sensor of Claim 6, further comprising:

a coaxial cable coupled between the sensor coil and the oscillator circuit, the coaxial cable having a capacitance that acts as at least one of the capacitance circuit elements.

8. The proximity sensor of Claim 1, further comprising:

a coaxial cable coupled between the sensor coil and the oscillator circuit, the coaxial cable having an effective capacitance that is electrically coupled in parallel with the sensor coil, to thereby form an LC circuit.

9. The proximity sensor of Claim 1, wherein the sensor coil comprises:

a ceramic core; and

a conductor selected from the group consisting of platinum and molybdenum.

10. The proximity sensor of Claim 1, further comprising:

a peak detector coupled to receive the proximity signal and operable, in response thereto, to determine a peak value of the proximity signal.

11. A turbine blade proximity control system for controlling proximity of each of a plurality of turbine blades to a non-rotating turbine component, comprising:

a sensor coil;

an oscillator circuit coupled to the sensor coil and operable to supply a sensor signal that is frequency modulated based on the proximity of the sensor coil to each of the turbine blades;

a frequency modulation (FM) detector adapted to receive the frequency modulated sensor signal and operable, in response thereto, to supply a proximity signal having an amplitude that varies with, and is representative of, the proximity of each of the turbine blades to the non-rotating turbine component; and

a controller coupled to receive the proximity signal from the FM detector and operable, in response thereto, to control the proximity of the turbine blades to the non-rotating turbine component.

12. The system of Claim 11, wherein:

the non-rotating turbine component is either a turbine case or a component coupled to the turbine shroud; and

the controller controls the proximity of the turbine blades to the non-rotating turbine component by controlling turbine shroud temperature.

13. The system of Claim 12, wherein the controller, in response to the proximity signal, supplies one or more valve control signals, and wherein the system further comprises:

one or more valves in fluid communication between a cooling air source and the turbine shroud, each valve having an actuator coupled to receive one or more of the valve control signals and operable, in response thereto, to selectively move its associated valve between an open position and a closed position, to thereby selectively cool the turbine case.

14. The system of Claim 11, further comprising:

an display coupled to receive the proximity signal from the FM detector and operable, in response thereto, to supply a visual display of the proximity of each of the turbine blades to the turbine shroud.

15. The system of Claim 11, wherein the oscillator circuit includes one or more capacitance circuit elements electrically coupled in parallel with the sensor coil.

16. The system of Claim 15, further comprising:

a coaxial cable coupled between the sensor coil and the oscillator circuit, the coaxial cable having a capacitance that acts one of the capacitance circuit elements.

17. The system of Claim 11, further comprising:

a coaxial cable coupled between the sensor coil and the oscillator circuit, the coaxial cable having an effective capacitance that is electrically coupled in parallel with the sensor coil, to thereby form an LC circuit.

18. The system of Claim 11, wherein the sensor coil comprises:

a ceramic core; and

a conductor selected from the group consisting of platinum and molybdenum.

19. The system of Claim 11, further comprising:

a peak detector coupled to receive the proximity signal and operable, in response thereto, to determine a peak value of the proximity signal.

20. A gas turbine engine, comprising:

a turbine case;

a turbine wheel rotationally mounted within the turbine case;

a plurality of turbine blades extending from the turbine wheel toward the turbine case; and

a turbine blade proximity sensor system including:

a sensor coil disposed at least partially within the turbine case,

an oscillator circuit coupled to the sensor coil and operable to supply a sensor signal that is frequency modulated based on the proximity of the sensor coil to each of the turbine blades; and

a frequency modulation (FM) detector circuit coupled to receive the frequency modulated sensor signal and operable, in response thereto, to supply a proximity signal having an amplitude that varies with, and is representative of, the proximity of each of the turbine blades to either the turbine case or one or more components mounted thereto.

21. A method of determining proximity of each of a plurality of turbine blades to a non-rotating turbine component, comprising the steps of:

supplying a sensor signal that is frequency modulated based on the proximity of each of the turbine blades to the non-rotating turbine component;

demodulating the frequency modulated sensor signal, to thereby supply a proximity signal having an amplitude that varies with, and is representative of, the proximity of each of the turbine blades to the non-rotating turbine component.

22. The method of Claim 21, further comprising the step of:

varying the proximity of each of the turbine blades to the non-rotating turbine component in response to the proximity signal.

23. The method of Claim 22, further comprising the step of:

varying non-rotating turbine component temperature in response to the proximity signal, to thereby vary the proximity of each of the turbine blades to the non-rotating turbine component.

24. The method of Claim 21, further comprising:

detecting a peak value of the proximity signal amplitude variations, to thereby determine a minimum turbine blade proximity to the non-rotating turbine component.

25. A proximity sensor for sensing proximity of a rotating element to another element, comprising:

a sensor coil;

an oscillator circuit coupled to the sensor coil and operable to supply a sensor signal that is frequency modulated based on the proximity of the sensor coil to the rotating element;

a frequency modulation (FM) detector circuit adapted to receive the frequency modulated sensor signal and operable, in response thereto, to supply a proximity signal having an amplitude that varies with, and is representative of, the proximity of the rotating element to the other element.